CLAIMS (Amended in accordance with Art. 34(2) (b) PCT)

1. An apparatus for measuring geometrical profiles of periodic microstructures of a sample, the apparatus comprising

- a light source for emission of a light beam,

- polarizing means for polarizing the emitted light beam,

- focusing means for focusing the polarized light beam on the microstructures of the sample so as to provide, at a number of microstructures, a plurality of illumination angles simultaneously,

- a collection means for collecting light diffracted from the illuminated microstructures, the collection means being adapted to collect both the 0'th and higher diffraction orders,

- resolving means for resolving the collected light into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths, and

- a reconstruction algorithm for determining the geometrical profile of the illuminated microstructures, the reconstruction algorithm being adapted to perform the following steps:

  - comparing the resolved diffraction data with modeled diffraction data from a known geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known geometrical profile being selected from a database of pre-defined families of profiles, the selection being performed using minimum norm techniques,

  - repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

2. An apparatus according to claim 1, wherein the light source comprises a broadband light source, such as Xenon, Deuterium, or halogen lamp.

3. An apparatus according to claims 1 or 2, wherein the focusing means comprises a lens system.

4. An apparatus according to claim 1, wherein the light source comprises a substantially monochromatic light source, such as a laser.

5. An apparatus according to any of claims 1-4, wherein the collection means comprises a lens system.

6. An apparatus according to any of claims 1-5, wherein the focusing means and the collection means each comprises a lens system.

7. An apparatus according to claim 6, wherein the lens systems of the focusing means and the collection means are the same lens system.

8. An apparatus according to any of claims 1-7, wherein the polarizing means comprises a beam splitter, the beam splitter generating a reference beam and an illumination beam.

9. An apparatus according to any of claims 1-8, wherein the resolving means comprises an imaging detection system.

10. An apparatus according to claim 9, wherein the imaging detection system comprises means for generating a plurality of light beams having different center wavelengths and propagating in different directions.

11. An apparatus according to claim 10, wherein the imaging detection system further comprises an array of light sensitive elements, the array of light sensitive elements being adapted to be illuminated by the generated plurality of light beams.

12. An apparatus according to claim 9, wherein the imaging detection system comprises an array of color light sensitive elements, the color sensitivity being provided by a color mask positioned in front of the light sensitive elements.

13. An apparatus according to any of claims 11 or 12, wherein the array of light sensitive elements forms part of a CCD array, an InGaAs array, a PbSe array, a PbS array, a Superconduction Tunnel Junction array, or any combination thereof.

14. A non-destructive method for measuring geometrical profiles of periodic microstructures of a sample, the method comprising the steps of:

- providing a light source for emission of a light beam,

- polarizing the emitted light beam, and transmitting the polarized light beam to a refractive member,

- focusing the transmitted and polarized light beam on the microstructures of the sample using the refractive member so as to provide, at a number of microstructures, a plurality of illumination angles simultaneously,

- collecting light diffracted from the illuminated microstructures using a collection system, the collection system being adapted to collect both the 0'th and higher diffraction orders, and resolving the collected light into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths, and

- determining the geometrical profile of the illuminated microstructures using a reconstruction algorithm, the reconstruction algorithm comprising the steps of:

  - comparing the resolved diffraction data with modeled diffraction data from a known geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known geometrical profile being selected from a database of pre-defined families of profiles, the selection being performed using minimum norm techniques,

  - repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

15. Use of the method according to claim 14 for monitoring formation or alternation of periodic microstructures.

16. The use of the method according to claim 15, wherein the formation or alternation is monitored by monitoring respective formation or alternation of the microstructures.

17. The use of the method according to claim 15, wherein the formation or alternation is monitored by monitoring formation or alternation of an associated target structure.

18. The use of the method according to claim 15, wherein the periodic microstructures are formed or altered in a semiconductor, metallic, or dielectric material, or combination thereof.

19. The use of the method according to claim 18, wherein the periodic microstructures are formed or altered using an etching method, such as reactive plasma etching and wet etching.

20. The use of the method according to claim 18, wherein the periodic microstructures are formed using a lithographic process.

21. The use of the method according to claim 18, wherein the periodic microstructures are formed or altered using an epitaxial growth process.

22. The use of the method according to claim 18, wherein the periodic microstructures are formed or altered using a film deposition process.

23. The use of the method according to claim 18, wherein the periodic microstructures are formed or altered using an oxidation process.

24. A computer program code for determining a geometrical profile of illuminated microstructures when said program code is run on a computer, the program code being adapted to perform the following steps:

- resolving collected light data into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths,

- comparing the resolved diffraction data with modeled diffraction data from a known geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known geometrical profile being selected from a database of pre-defined families of profiles, the selection being performed using minimum norm techniques, and

- repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

25. A computer readable medium carrying a computer program code for determining a geometrical profile of illuminated microstructures when said program code is run on a computer, the program code being adapted to perform the following steps:

- resolving collected light data into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths,

- comparing the resolved diffraction data with modeled diffraction data from a known geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known geometrical profile being selected from a database of pre-defined families of profiles, the selection being performed using minimum norm techniques, and

- repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

26. An apparatus for measuring geometrical profiles of periodic microstructures of a sample, the apparatus comprising

- a light source for emission of a light beam,

- polarizing means for polarizing the emitted light beam,

- focusing means for focusing the polarized light beam on the microstructures of the sample so as to provide, at a number of microstructures, a plurality of illumination angles simultaneously,

- a collection means for collecting light diffracted from the illuminated microstructures, the collection means being adapted to collect both the 0'th and higher diffraction orders,

- resolving means for resolving the collected light into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths, and

- a reconstruction algorithm for determining the geometrical profile of the illuminated microstructures, the reconstruction algorithm being adapted to perform the following steps:

  - comparing the resolved diffraction data with modeled diffraction data from a known parameterized geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known parameterized geometrical profile being selected by variation of the geometrical profile parameters, the selection of the parameters being performed using minimum norm techniques,

  - repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

27. An apparatus according to claim 26, wherein the light source comprises a broadband light source, such as Xenon, Deuterium, or halogen lamp.

28. An apparatus according to claims 26 or 27, wherein the focusing means comprises a lens system.

29. An apparatus according to claim 26, wherein the light source comprises a substantially monochromatic light source, such as a laser.

30. An apparatus according to any of claims 26-29, wherein the collection means comprises a lens system.

31. An apparatus according to any of claims 26-30, wherein the focusing means and the collection means each comprises a lens system.

32. An apparatus according to claim 31, wherein the lens systems of the focusing means and the collection means are the same lens system.

33. An apparatus according to any of claims 26-32, wherein the polarizing means comprises a beam splitter, the beam splitter generating a reference beam and an illumination beam.

34. An apparatus according to any of claims 26-33, wherein the resolving means comprises an imaging detection system.

35. An apparatus according to claim 34, wherein the imaging detection system comprises means for generating a plurality of light beams having different center wavelengths and propagating in different directions.

36. An apparatus according to claim 35, wherein the imaging detection system further comprises an array of light sensitive elements, the array of light sensitive elements being adapted to be illuminated by the generated plurality of light beams.

37. An apparatus according to claim 34, wherein the imaging detection system comprises an array of color light sensitive elements, the color sensitivity being provided by a color mask positioned in front of the light sensitive elements.

38. An apparatus according to any of claims 36 or 37, wherein the array of light sensitive elements forms part of a CCD array, an InGaAs array, a PbSe array, a PbS array, a Superconduction Tunnel Junction array, or any combination thereof.

39. A non-destructive method for measuring geometrical profiles of periodic microstructures of a sample, the method comprising the steps of:

- providing a light source for emission of a light beam,

- polarizing the emitted light beam, and transmitting the polarized light beam to a refractive member,

- focusing the transmitted and polarized light beam on the microstructures of the sample using the refractive member so as to provide, at a number of microstructures, a plurality of illumination angles simultaneously,

- collecting light diffracted from the illuminated microstructures using a collection system, the collection system being adapted to collect both the 0'th and higher diffraction orders, and resolving the collected light into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths, and

- determining the geometrical profile of the illuminated microstructures using a reconstruction algorithm, the reconstruction algorithm comprising the steps of:

  - comparing the resolved diffraction data with modeled diffraction data from a known parameterized geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known parameterized geometrical profile being selected by variation of the geometrical profile parameters, the selection of the parameters being performed using minimum norm techniques,

  - repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

40. Use of the method according to claim 39 for monitoring formation or alternation of periodic microstructures.

41. The use of the method according to claim 40, wherein the formation or alternation is monitored by monitoring respective formation or alternation of the microstructures.

42. The use of the method according to claim 40, wherein the formation or alternation is monitored by monitoring formation or alternation of an associated target structure.

43. The use of the method according to claim 40, wherein the periodic microstructures are formed or altered in a semiconductor, metallic, or dielectric material, or combination thereof.

44. The use of the method according to claim 43, wherein the periodic microstructures are formed or altered using an etching method, such as reactive plasma etching and wet etching.

45. The use of the method according to claim 43, wherein the periodic microstructures are formed using a lithographic process.

46. The use of the method according to claim 43, wherein the periodic microstructures are formed or altered using an epitaxial growth process.

47. The use of the method according to claim 43, wherein the periodic microstructures are formed or altered using a film deposition process.

48. The use of the method according to claim 43, wherein the periodic microstructures are formed or altered using an oxidation process.

49. A computer program code for determining a geometrical profile of illuminated microstructures when said program code is run on a computer, the program code being adapted to perform the following steps:

- resolving collected light data into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths,

- comparing the resolved diffraction data with modeled diffraction data from a known parameterized geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known parameterized geometrical profile being selected by variation of the geometrical profile parameters, the selection of the parameters being performed using minimum norm techniques, and

- repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.

50. A computer readable medium carrying a computer program code for determining a geometrical profile of illuminated microstructures when said program code is run on a computer, the program code being adapted to perform the following steps:

- resolving collected light data into diffraction data relating to illumination angles, polarization angles, diffraction orders, and illumination wavelengths,

- comparing the resolved diffraction data with modeled diffraction data from a known parameterized geometrical profile, the comparison taking both the 0'th and higher diffraction orders into account, the known parameterized geometrical profile being selected by variation of the geometrical profile parameters, the selection of the parameters being performed using minimum norm techniques, and

- repeating adjusting the geometrical profile of the known selected geometrical profile until the modeled diffraction data matches the resolved diffraction data within predetermined tolerances.